Exhibit 4

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

OYSTER OPTICS, LLC,	
Plaintiff,	**Civil Action No. 2:16-cv-01302**
v.	
CORIANT (USA) INC., ET AL.	**LEAD CASE**

EXPERT REPORT OF DR. GEORGE PAPEN REGARDING INVALIDITY OF U.S. PAT. NO. 6,476,952; U.S. PAT. NO. 6,594,055; U.S. PAT. NO. 7,099,592; U.S. PAT. NO. 7,620,327; AND U.S. PAT. NO. 8,374,511

TABLE OF CONTENTS

also supplement my invalidity analysis if any relevant information is provided in Oyster's expert reports.

4. If called on to testify as an expert witness in this matter, I anticipate that my testimony will concern my opinions and analyses of the issues considered in this report. In connection with my anticipated testimony at trial or at an evidentiary hearing, I may provide an overview of basic engineering and scientific principles involved in fiber optic communications, including the evolution of such methods up to and including the present. I may also provide an overview of the Asserted Patents and their file histories. I may also discuss my own work, teaching, and publications in the field, and knowledge of the state of the art during and prior to and including the early 2000s. I may rely on handbooks, textbooks, technical literature and the like to help in showing the state of the art and evolution of the relevant technology.

II. BASES FOR OPINIONS

A. Qualifications

5. My experience and education are detailed in my curriculum vitae, which is attached as Exhibit A to this report. I hold a doctorate in Electrical and Computer Engineering from the University of Wisconsin, Madison. I have over 25 years of experience in the field of fiber optics. My research and scholarly work include building and deploying laser remote sensing systems (LIDARS) and building and testing optical lightwave systems including data center networks. When I refer to "fiber optics", this includes fiber optic communications component, communications systems, and fiber-based LIDAR applications.

6. I am employed as a tenured Professor in the Department of Electrical and Computer Engineering at the University of California at San Diego where I have taught and researched since 2002. Prior to that, I was a professor and associate professor at the University of

- ECE 181 Physical Optics and Fourier Optics
- ECE 182 Electromagnetic Optics, Guided-Wave, and Fiber Optics
- ECE 183 Optical Electronics
- ECE 185 Lasers and Modulator
- ECE 240a Lasers and Optics (graduate-level class)
- ECE 240c Optical modulation and detection (graduate-level class)

15. A person of ordinary skill in the art would have built on this knowledge foundation with on-the-job experience in areas directly associated with the Asserted Patents such as optical communication system design, optical component design and fabrication, optical testing, and communication standards. A person with a bachelor's degree as described above would have at least five years of applicable experience, or a graduate degree.

16. I understand that a person having ordinary skill in the art is a hypothetical person that is used to analyze the prior art without the benefit of hindsight. A person of ordinary skill in the art is presumed to be one who thinks along the lines of conventional wisdom in the art and is not one who undertakes to innovate, whether by extraordinary insights or by patient and often expensive systematic research. A person of ordinary skill in the art is not the judge, nor a layperson, nor one skilled in remote arts, nor a genius in the art, nor the inventor.

17. I understand that the hypothetical person of ordinary skill in the art is presumed to have knowledge of all references that are sufficiently related to one another and

to the pertinent art and to have knowledge of all arts reasonably pertinent to the particular problem that the claimed invention addresses.

III. SUMMARY OF OPINIONS

18. Based on all of the information I reviewed and considered, my own knowledge and expertise, and my opinion as to the level of ordinary skill in the art at the time described herein, it is my opinion that each of the Asserted Claims are either anticipated by, and/or would have been obvious at the time of filing of the application to which each patent claims priority, to a person of ordinary skill in the art, in view of the references and other publications cited in this report.

19. Additionally, based on my review, it is my opinion that Claims do not satisfy the written description or enablement requirements pursuant to 35 U.S.C. § 112.

IV. BACKGROUND OF FIBER OPTIC COMMUNICATIONS COMPONENTS AND SYSTEMS

20. In this section, I will discuss the concepts and techniques that were known to a person of ordinary skill in the art prior to the filing of the applications that led to the Asserted Patents.

A. Fiber-Optic Transmission

21. In the prior art, it was known to use fiber-optic communications systems to convey information by modifying the characteristics of an electromagnetic wave, called a carrier wave. For the purpose of transmission, it was known in modern communication systems to first map information into electronic signals that were either analog or digital. Analog systems typically mapped information into a continuous physical quantity. Digital

system typically mapped or encoded information into a sequence of discrete logical symbols.

22. It was known that point-to-point digital communication system conveys data between a source and a destination. A typical goal of digital communication system engineering at the time was to provide the system with beneficial qualities and attributes such as information rate, reliability, and the energy-efficient use of the communication channel. Various technologies and techniques presented the designer with well-known trade-offs among these attributes.

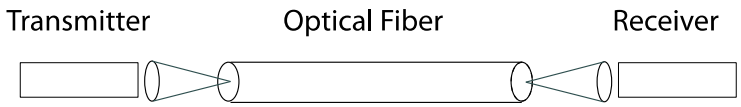
23. It has long been known that lightwave communication system can be distinguished from other communication systems that use carrier waves by the frequency of the carrier wave. Radio-frequency communications systems such as WiFi, Bluetooth, and cell phones use carrier waves with frequencies in the megahertz (10^6 Hertz) to gigahertz range (10^9 Hertz). In contrast, lightwave frequencies are higher, in the terahertz range (10^{14} Hertz).

24. As was known, the length of one cycle of the lightwave in space is called the wavelength. The wavelength of a lightwave is on the order of one micron or 10^{-6} meters. A phase shift of 360^o (or 2π radians) of the carrier wave in space corresponds to one wavelength. The carrier wave also has a polarization, which is the orientation of the electromagnetic field in space. This orientation changes over time.

25. It was known that an ideal carrier frequency can be thought of as a perfect tone, such as that generated by a tuning fork for music. This ideal carrier wave has a well-defined amplitude, phase, and frequency. This kind of optical carrier is called a coherent carrier. In principle, any combination of the properties of an optical carrier can be used to

convey information using a coherent carrier. A noncoherent optical carrier has a completely random phase. It was known that a system using a noncoherent source could convey information using only a restricted set of the properties of a lightwave. Most systems that used a noncoherent source modified the power or the intensity of the noncoherent carrier because this modification does not require the use of phase. These systems are called intensity-modulated systems.

26. As was known, a general point-to-point guided fiber-optic communication system consisted of a transmitter, a guided fiber-optic channel, and a receiver. Each of these known system elements is shown in the figure below.



A point-to-point fiber-optic communication system.

27. It was known that a common point-to-point fiber-optic communication system consisted of a transmitter, a transmission medium and a receiver. The known components that coupled, generated, guided, and photodetected optical signals, which comprised fiber-optic communication systems will be discussed separately. These components have attributes that are not always found in the corresponding components used in radio-frequency communication systems.

B. Prior Art Transmitters

28. It was known that an optical transmitter typically consisted of the following components: 1) An optical source that generated the optical carrier that conveys the information, 2) an encoder that mapped discrete logical symbols information into a sequence

of electrical pulses comprising an electrical waveform, and 3) a modulator that modified one or more characteristics of the optical carrier in response to the electrical waveform.

29. A person of ordinary skill knew how to use optical sources to provide an optical carrier used to convey information. The carrier wave was typically characterized by several parameters. For example, the amplitude of the electromagnetic wave is the "height" of the wave. The phase of the carrier wave describes the time at which the amplitude of the wave is zero. The frequency of the wave is the number of oscillations the wave executes in one second, measured in Hertz. The time of one cycle of the wave is called the temporal period of the lightwave and is the inverse of the frequency.

30. To provide fiber-optic communication with specific attributes such as reliability and the energy-efficient use of the communication channel, digital systems in the prior art used an encoder to modify the input stream of digital symbols so as to achieve one or more of the desired attributes. This modification involves constructing a new set of symbol pulses comprising the electrical waveform used for modulation from the original set of digital symbols at the input to the communication system.

31. It was known prior to the filing of the applications that led to the Asserted Patents that digital encoding involves taking a block of input digital symbols and generating a new block of encoded output digital symbols where size of the blocks need not be the same. To perform this operation, the system commonly utilized memory to store the symbols within the encoder. This encoding was known to increase the redundancy of the information to improve reliability of communication or create patterns of symbols that are more readily distinguished at the receiver.

421. Nevertheless, should a POSITA have sought to include a "tap signal device indicating a fiber tap" under my understanding of tap, it would have been obvious and merely a design choice because, as exemplified by Leone which predates the '592 patent by several years, indicators on faceplates were well-known and available.

422. In the mid to late 1990s, Pirelli Cavi S.p.A and its U.S. affiliates, including Pirelli Cables and Systems LLC, ("Pirelli")[20] developed and sold a carrier grade fiber optics communication system utilizing wavelength division multiplexing. The prior art card defining the relevant prior art system in this section of my report is a receiver card identified as the RXT-DM-M and RXT-DM-N ("RXT"). The RXT, together with the compatible transmitter card (WCM) and the compatible optical fiber platform into which the cards are installed (WaveMux™ 3200 DWDM system, WaveMux™ 6400 DWDM system, and the WaveMux/TeraMux™ 6400 Hyper-DWDM system, and the Cisco ONS 15800[21]) is referred to herein as the "Pirelli System." For the purposes of my analysis, the differences in the platforms predominantly relate to capacity (both the number of channels, and data rates) and are not significant unless otherwise noted herein. As indicated below, the RXT cards include the same energy level detector, and were the same across these product lines. As such, the bulk of my analysis focuses on the RXT cards in connection with the Pirelli WaveMux/TeraMux Hyper-DWDM platform in the 1998 to 1999 timeframe.

[20] Discussions with Mr. Bonato and Mr. Gazzola.

[21] Cisco Systems, Inc. (Cisco) completed its acquisition of Pirelli S.p.A on February 16, 2000. https://www.thefreelibrary.com/Cisco+Systems+Completes+the+Acquisition+of+Pirelli+Optical+Systems.-a059703832. I understand that after Cisco acquired Pirelli, the Pirelli WaveMux HyperDWDM system was rebranded as the Cisco ONS 15800. Cisco was offering product literature on the Cisco ONS 15800 system, with RXT cards, for sale in the United States at least prior to July 9, 2000. For example, see the Cisco ONS 15800 HDWDM System Technical Specification, dated April 11, 2000 ("Cisco ONS 15800 Tech Spec 2000") and the Cisco ONS 15800 System Overview, February 15, 2000 ("Cisco ONS 15800 Overview 2000"). I further understand that the Cisco ONS 15800 is a legacy product to the ONS 15454 and NCS2000k products that Plaintiff accuses of infringement. To the extent Plaintiff accuse circuitry or components of infringement that are present in the Pirelli System, I reserve the right to challenge the validity of the claims based on Plaintiff's assertions.

423. The Pirelli System was publicly demonstrated, offered for sale, sold and/or commercially used in the United States by Pirelli and its customers prior to each of the relevant potential priority dates in the case: (i) July 9, 2000 (the date that is one year prior to the filing date of the U.S. provisional patent application to which the '511 and '327 patent claim priority; and also prior to (ii) July 3, 2001 (one year prior to the filing date of the '327 patent); (iii) July 9, 2001 (the earliest possible invention date, as evidenced filing date of the U.S. provisional application to which the '327 and '511 patents claim priority); and (iv) July 3, 2002 (the filing date of the '327 patent). As such, I understand that the Pirelli System is prior art to the '327 and '511 patents at least under 35 U.S.C. §§ 102(a), (b) and (g).[22]

424. Based on my review of documents and discussions with Mr. Bonato and Mr. Gazzola, the Pirelli System was reduced to practice, on sale, publicly demonstrated and in commercial use in the United States prior to July 9, 2000. At least the following documents, together with the sales and technical documents that I reference further below, demonstrate the timing of the Pirelli System being reduced to practice, sold, offered for sale and publicly used:

- Carter, Wayne, "DWDM vendors up ante at OFC: Pirelli, Ciena and Lucent to offer higher capacity" Telephony Online, Mar. 2, 1998:

> Several vendor announcements at last week's Optical Fiber Conference demonstrate that ongoing advancements in dense wave division multiplexing are fueling an increasingly competitive equipment market. Pirelli Cables and Systems North America introduced the WaveMux 6400 system, a 64-channel, long-haul DWDM system
>
> Pirelli chose to double its previous capacity to 64 ports, even though the ITU-T grid identifies 40 channels as its standard, said Neal Stoker, Pirelli's North American marketing director. "We didn't want to let standards stop us" from following the common doubling practice, he said.

[22] Furthermore, I cite to one or more publications below that themselves constitute printed publication prior art, including the RXT Handbook and the Hyper-DWDM Specification, which published no later than October, 1998 that each would render obvious the asserted claims of the '327 and '511 patents.

- ECE 181 Physical Optics and Fourier Optics
- ECE 182 Electromagnetic Optics, Guided-Wave, and Fiber Optics
- ECE 183 Optical Electronics
- ECE 185 Lasers and Modulator
- ECE 240a Lasers and Optics (graduate-level class)
- ECE 240c Optical modulation and detection (graduate-level class)

15. A person of ordinary skill in the art would have built on this knowledge foundation with on-the-job experience in areas directly associated with the Asserted Patents such as optical communication system design, optical component design and fabrication, optical testing, and communication standards. A person with a bachelor's degree as described above would have at least five years of applicable experience, or a graduate degree.

16. I understand that a person having ordinary skill in the art is a hypothetical person that is used to analyze the prior art without the benefit of hindsight. A person of ordinary skill in the art is presumed to be one who thinks along the lines of conventional wisdom in the art and is not one who undertakes to innovate, whether by extraordinary insights or by patient and often expensive systematic research. A person of ordinary skill in the art is not the judge, nor a layperson, nor one skilled in remote arts, nor a genius in the art, nor the inventor.

17. I understand that the hypothetical person of ordinary skill in the art is presumed to have knowledge of all references that are sufficiently related to one another and

difference in phase between successive signal transmissions as opposed to encoding each bit individually. Hooijmans, 71-72.

476. As was also known to a person of ordinary skill in the art, amplitude shift keying (ASK), while simple to implement, had significant drawbacks, commonly understood in the optical communications field. For example, Hooijman described that transmitted power can be "in the carrier and thus not used for information transmission. This is a major drawback of the ASK modulation scheme." Hooijmans, 65. A person of ordinary skill in the art would likewise know that intensity modulation is not an energy-efficient method to convey information, requiring more power to transmit the same amount of information the same distance in an optical fiber as compared to other techniques

477. According to Hooijmans, "[t]he obvious advantage of PSK [is] high sensitivity." Hooijmans, 71. As understood by a person of ordinary skill in the art, for the same transmitted power, a PSK receiver can reliably detect PSK signals over a longer distance of fiber as compared to an intensity-modulated system. However, PSK systems require more complexity than ASK (or intensity modulation) schemes. Hooijmans further discloses that DPSK is a "way of overcoming the problems associated with pure PSK, while at the same time exploiting the advantages of phase modulation." Hooijmans, 71.

478. In my opinion, a person of skill in the art of the invention would have understood that the phase modulation techniques disclosed by Hooijmans could be implemented without affecting the amplitude of the modulated signal. Furthermore, a person of ordinary skill in the art understands how to alter the phase of light while maintaining amplitude constant, for example, using simple $LiNbO_3$ electro-optic phase modulator. To the extent Plaintiff argues that the claims

encompass modulation techniques in which amplitude varies during phase modulation, that was clearly within the art as well. *See, e.g.*, Section IV.

479. In my opinion, a person of skill in the art at the time of the invention, with knowledge of Pirelli and Hooijmans would have considered it obvious to implement phase modulation of Hooijmans in the fiber optic communication system of Pirelli. Initially, Pirelli and Hooijmans are directed to the same subject matter, namely optical fiber telecommunications in carrying out similar methods for optical telecommunications.

480. In addition, Hooijmans discloses achieving high sensitivity receivers through use of phase modulation. *See, e.g.,* Hooijmans, 70-72. A person of skill in the art at the time of the invention would have understood that Hooijmans would have had beneficial improvements to Pirelli.

481. It would have been obvious to try the resulting combination as it amounts to merely choosing from a finite number of identified, predictable solutions (phase modulation as opposed to amplitude modulation), with a reasonable expectation of success (allowing the Pirelli receiver to achieve high sensitivity (as taught by Hooijmans).

482. Further motivation for this combination includes applying a known technique (Hooijmans' phase modulation) to a known device (a laser-based transmitter having a modulator such as the one disclosed by Pirelli) that was ready for improvement to yield predictable results (allowing the Pirelli transceiver to transmit optical signals capable of being detected with high sensitivity as taught by Hooijmans).

iv. Claim 1 of the '327 Patent Is Obvious over the Pirelli System

> 1pre. "A transceiver card for a telecommunications box for transmitting data over a first optical fiber and receiving data over a second optical fiber, the card comprising:"

483. To the extent the preamble is limiting, Pirelli embodied and rendered obvious a transceiver card for a telecommunications box for transmitting data over a first optical fiber and receiving data over a second optical fiber.

484. The Pirelli System was an optical fiber communication system:

> The WaveMux system is a Hyper-Dense Wavelength Division Multiplexing (HDWDM) and Optical Amplification System in the 1550 nm transmission window. Primarily designed for SONET/SDH transport, the WaveMux system can carry up to 128 channels at 2.5 Gbps (OC-48/STM-16) on a single pair of Single Mode Fibers (ITU-T G.652). The current release allows for 32 channels at 2.5 Gbps and offers a full upgrade path to 64/128 hannels (as described in Section 4 and Section 5).

[WaveMux Overview, p. 2-1]; *see also* [DWDM Overview, p. 1-1]

485. The Pirelli System was an optical fiber communication system based parallel optical fiber paths:

discloses both design choices. Thus, in my opinion this claim is either embodied or rendered obvious based on the comparator limitation of claim 5 for the reasons set forth in that claim.

Dated January 10, 2018

Dr. George Papen